Calculating Conductance of Ion Channels

Andrew Pohorille and Michael Wilson

Abstract

We have simulated two small ion channels in a water/membrane system, which consists of 71,000-72,000 atoms, and have estimated the conductance by way of counting ions crossing these channels in applied field. The calculated values of conductance have been compared with predictions of the electrodiffusion model. In a recently developed theoretical framework, all commonly used assumptions of the model can be tested. If they are satisfied, which is often the case, the approach provides a rigorous way to extrapolate conductance calculated at one voltage to other voltages. This, in turn, allows for efficient estimations of current-voltage dependence, examining rectifying behavior of channels and calculating the reversal potential. Furthermore, the consistency of the results can be precisely tested. Simulations at microsecond time scales are required to sufficiently reduce statistical errors and separate them from possible systematic errors. Only then the accuracy of the proposed approach can be properly tested. Linking simulations with electrophysiology provides a stringent, highly relevant test for the correctness of computer simulations of ion channels. Considering biological, medical and pharmaceutical importance of these proteins, results of the proposed study might motivate the development of improved hardware and software that would enable applying a similar strategy to more complex channels at longer times.